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June 10, 2011

Ms. Jocelyn D. Boyd
Chief Clerk
Public Service Commission of South Carolina
Post Office Drawer 11649
Columbia, SC 29211

Re: Amended Project Development Application of Duke Energy Carolinas, LLC for Approval of Decision to Incur Nuclear Generation Pre-Construction Costs
Docket No. 2011-20-E

Dear Ms. Boyd:

Enclosed please find for filing and consideration the Late-Filed Hearing Exhibit No. 5 on behalf of the South Carolina Coastal Conservation League, together with Certificate of Service reflecting service upon the parties of record.

With kind regards I am

Sincerely,

Robert Guild

Encl.
CC: Parties of Record

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2011
PSC SC
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BEFORE
THE PUBLIC SERVICE COMMISSION OF
SOUTH CAROLINA
DOCKET NO. 2011-20-E

In the Matter of Amended Project Development Application of Duke Energy Carolinas, LLC for Approval of Decision to Incur Nuclear Generation Pre-Construction Costs	))))))	**Certificate of Service**

I hereby certify that on this date I served the above LATE-FILED HEARING EXHIBIT NO. 5 by placing copies of same in the United States Mail, first-class postage prepaid, addressed to:

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June 10, 2011

Robert Guild

BEFORE THE PUBLIC SERVICE COMMISSION
OF
SOUTH CAROLINA
DOCKET NO. 2011-20-E

In the Matter of	)
Amended Project Development Application	)
of Duke Energy Carolinas, LLC for Approval	)
of Decision to Incur Nuclear Generation Pre-	)
Construction Costs	)

LATE-FILED HEARING EXHIBIT NO. 5
on behalf of the
South Carolina Coastal Conservation League

QUESTION

Please identify the proponents of pebble bed reactors, and describe the current status of pebble bed reactor development.

ANSWER:

Pebble Bed reactors have been championed by various governments and researchers in the last 50 years.

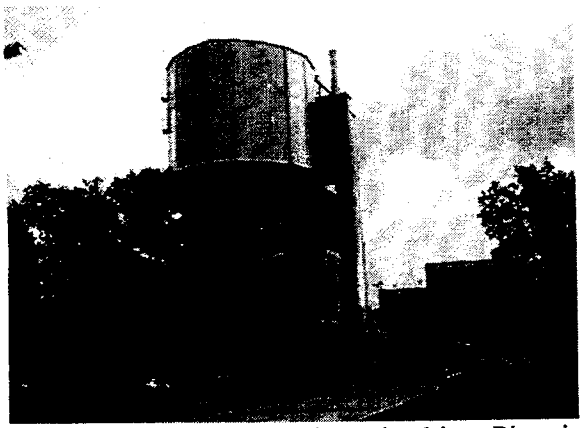
In the United States, engineers at MIT (Andrew Kadak) have been significant champions of the technology. The MIT project web page appears not to have been updated for several years, and does not readily describe the current status of the MIT efforts.

The first pebble bed reactor was developed in Germany in the 1960s, but was closed after the Chernobyl accident, when it was discovered that the German plant had been releasing radioactive dust as a byproduct of the process (and that the developers had tried to attribute this radioactivity to the Chernobyl accident). The German developers closed shop in 1991. The South African government electric utility ESKOM was an early promoter, and created PBMR, Ltd. in 1999 to develop the concept. Efforts to build a pebble bed reactor in that country stalled in 2009 as the project had not become workable. China has invested heavily in pebble bed reactor technology, but has not put on line a working reactor.

The following articles and excerpts of Wikipedia postings provide a fuller description of the history of pebble bed reactors. There has been comparatively little written about PBRs in recent years.

I. Will the Fukushima nuclear reactor disaster give pebble reactors a second lease on life?

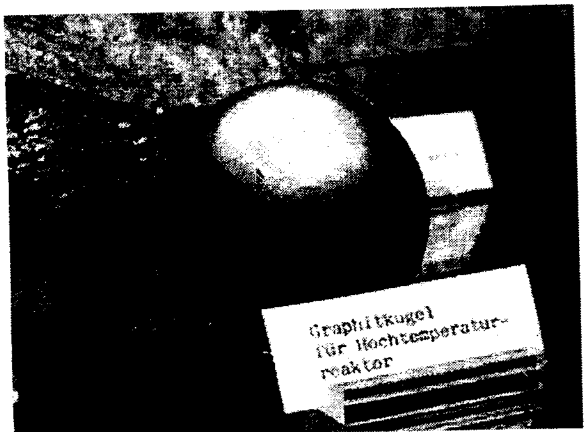
By *Sorin Adam Matei*
– March 15, 2011 **Posted in:** Current Affairs, Digital News



As the reactor failure at the Fukushima Plant in the aftermath of the Sendai earthquake increases public apprehension of nuclear technology, the future of this type of energy production might not be as bleak as it looks. There is one design that seems to be a marriage made in heaven between safety and efficiency. An experimental design, called pebble bed reactor, uses small, golf size balls of graphite instead of fuel rods to generate heat. There are about 360,000 balls in a reactor and 3,000 of them are changed daily. The advantage of this design is that the pebbles capture more neutrons as the reactor heats up. This means that the reactor cannot overheat or explode, since it has a negative feedback. As temperature raises the reactivity declines, reducing in turn the temperature. This allows the operators to remove part of the pebbles during the low portion of the heat cycle. This process is described in more technical terms by Popular Mechanics

A typical pebble-bed reactor would function somewhat like a giant gumball machine. The design calls for a core filled with about 360,000 of these fuel pebbles—"kernels" of uranium oxide wrapped in two layers of silicon carbide and one layer of pyrolytic carbon, and embedded in a graphite shell. Each day about 3000 pebbles are removed from the bottom as fuel becomes spent. Fresh pebbles are added to the top, eliminating the need to shut down the reactor for refueling. Helium gas flows through the spaces between the spheres, carrying away the heat of the reacting fuel. This hot gas—which is inert, so a leak wouldn't be radioactive—can then be used to spin a turbine to generate electricity, or serve more exotic uses such as produce hydrogen, refine shale oil or desalinate water.

The pebbles are fireproof and almost impossible to use for weapons production. The spent fuel is easy to transport and store,



though there still remains the long-term problem of where to store it. And the design of the nuclear reactor is inherently meltdown-proof. If the fuel gets too hot, it begins absorbing neutrons, shutting down the chain reaction. In 2004, the cooling gas and secondary safety controls were shut off at an experimental pebble-bed reactor in China—and no calamity followed, says MIT professor Andrew Kadak, who witnessed the test.

Pebble-bed reactors also could be far more cost-effective than Gen II plants, which had an average construction time of more than nine years. Even proposed Gen III designs have an estimated build time of more than five years. Kadak's group at MIT has developed a pebble-bed design in which every part is small and light enough to be shipped by train and truck, so the components could be mass-produced off-site.

Fourth-generation nuclear power plants differ radically from current reactors by replacing water coolants and moderators, reaching higher temperatures, and gaining the potential to create hydrogen, as well as electricity.

One of the six Gen IV designs under consideration is the meltdown-proof pebble-bed reactor, which uses grains of uranium encased in balls of graphite as fuel. Helium gas is heated as it circulates through a vessel of these pebbles [1] and then powers a turbine [2] to generate electricity. A heat exchanger [3] can transfer heat from the helium to adjacent facilities [4] for the production of hydrogen. The plant relies on "passive safety": If the cooling system fails, the nuclear reaction grinds to a halt on its own.

The Bulletin of Atomic Scientists, however, disagrees with the view that pebble bed reactors are intrinsically safe. The authors of a recent article that announced the South African government's decision to shelve a pebble bed reactor believe that the temperatures in the reactor can go far higher than expected and that the constant rubbing of the pebbles against each other could create radioactive graphite dust. Furthermore, they believe that the graphite in the balls can ignite and burn with a lot of smoke, which would spread radioactivity far and wide. The Chernobyl disaster was particularly harmful because the graphite moderators in the reactors were ignited and the smoke generated traveled across Europe. Yet, again, the proponents of pebble bet reactors believe that such scenario cannot happen due to the negative feedback implicit in this power generation technology.

For now, the technology has only been tried in Germany and China, both countries putting it on the back burner due to prototyping and translation costs. Yet, if it will ever work, it could be a true revolution in nuclear power generation.

II. Pebble Bed Nuclear Reactors

excerpts from Wikipedia posting, last viewed June 2, 2011
http://en.wikipedia.org/wiki/Pebble_bed_reactor

The technology was first developed in Germany[1] but political and economic decisions were made to abandon the technology.[2] In various forms, it is currently under development by MIT, University of California at Berkeley, the South African company PBMR, General Atomics (U.S.), the Dutch company Romawa B.V., Adams Atomic Engines [1], Idaho National Laboratory, and the Chinese company Huanen g.[3]

...

China
China has licensed the German technology and is actively developing a pebble bed reactor for power generation.[19] The 10 megawatt prototype is called the **HTR-10**. It is a conventional helium-cooled, helium-turbine design. The program is at Tsinghua University in Beijing. The first 250-MW plant is scheduled to begin construction in 2009 and commissioning in 2013.[20] There are firm plans for thirty such plants by 2020 (6 gigawatts). By 2050, China plans to deploy as much as 300 gigawatts of reactors of which PBMRs will be a major component. If PBMRs are successful, there may be a substantial number of reactors deployed. This may be the largest planned nuclear power deployment in history.
Tsinghua's program for Nuclear and New Energy technology also plans in 2006 to begin developing a system to use the high temperature gas of a pebble bed reactor to crack steam to produce hydrogen. The hydrogen could serve as fuel for hydrogen vehicles, reducing China's dependence on imported oil. Hydrogen can also be stored, and distribution by pipelines may be more efficient than conventional power lines. See hydrogen economy.

South Africa
Main article: PBMR
In June 2004, it was announced that a new PBMR would be built at Koeberg, South Africa by Eskom, the government-owned electrical utility.[21] There is opposition to the PBMR from groups such as Koeberg Alert and Earthlife Africa, the latter of which has sued Eskom to stop development of the project.[22] In September 2009 the demonstration power plant was postponed indefinitely.[23] In February 2010 the South African government stopped funding of the PBMR because of a lack of customers and investors. PBMR Ltd started retrenchment procedures and stated the company intends to reduce staff by 75%.[24]

On the September 17, 2010 the South African Minister of Public Enterprises announced the closure of the PBMR.[25] The PMBR testing facility will likely be decommissioned and placed in a "care and maintenance mode" to protect the IP and the assets.

MIT PBMR web pages, last viewed June 2, 2011

MIT Nuclear Space Research, Andrew C. Kadak, Massachusetts Institute of Technology, September 2005

A Summary of Research Activities and Accomplishment, Andrew C. Kadak and Ronald Ballinger, 2nd International Topical Meeting on High Temperature Reactor Technology Beijing, China, September 22-24, 2004 http://web.mit.edu/pebble-bed/Presentation/PBRproject.pdfhttp://web.mit.edu/pebble-bed/Presentation/PBRproject.pdf

What Will it Take to Revive Nuclear Energy? Andrew C. Kadak, Massachusetts Institute of Technology, http://web.mit.edu/pebble-bed/Presentation/Revive.pdf [ca. 2001]